WATER SCIENCE SERIES

Compendium of Provincial Groundwater Science and Monitoring Projects: 2021-22

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Cover Images:
Clockwise from upper left:
Monitoring groundwater flow to Kootenay Lake using seepage meters. Photo: Natasha Neumann
Provincial observation well #503 in Chilliwack B.C. Photo: Kim Nguyen
Drill rig installing provincial observation well #506 on the Vaseux Creek alluvial fan. Photo: Nicole Pyett
Groundwater sampling demonstration and training at provincial observation well #481. Photo: Jun Yin

Acknowledgements

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PREFACE

The Provincial Groundwater Program originated in 1961 when the *Water Act* was revised to authorize the licensing of groundwater. The primary goals of the Groundwater Program are to increase the understanding of groundwater resources in British Columbia and to promote the sustainable management and protection of groundwater resources. To advance these goals, there is an ongoing need to improve scientific knowledge and monitoring of aquifer characteristics, groundwater availability, and groundwater interaction with surface water. This knowledge is central to the review of groundwater license applications in accordance with the 2016 *Water Sustainability Act* (*WSA*) and supports the goals of sustainable allocation and use of groundwater resources and science-based policy development.

The Groundwater Program is jointly administered by the Ministry of Land, Water and Resource Stewardship (LWRS), the Ministry of Environment and Climate Change Strategy (ENV), and the Ministry of Forests (FOR). Currently, groundwater science and monitoring projects are supported through three main funding envelopes:

- the Groundwater Science Fund, administered by the Water Protection & Sustainability Branch in LWRS;
- the Strategic Water and Air Monitoring Planning Process (SWAMPP), administered by the Environmental Monitoring & Analysis Branch in ENV; and,
- the Water Research Portfolio, administered by FOR.

The Groundwater Program also partners with other ministries and agencies in support of groundwater-related studies, including: the Ministry of Agriculture and Food (AF), the Ministry of Energy, Mines and Low Carbon Innovation (EMLI), Geoscience BC, the BC Oil and Gas Commission (OGC), the Geological Survey of Canada (GSC), universities, local governments, and First Nations.

This compendium is published under the *Water Science Series* to bring together a compilation of groundwater science and monitoring projects supported by the province during the 2021-22 fiscal year. The intent is to communicate to a wide audience, the nature of the projects undertaken and an overview of the project results. Linkages to key personnel and supporting references are provided within each summary.

CONTENTS

1. AQUIFER MAPPING

To effectively manage groundwater resources and the impacts of land development on groundwater availability and quality, it is essential to understand the existence and characteristics of B.C.'s aquifers. Identifying and mapping aquifers is often the first step in developing this understanding.

The Groundwater Wells and Aquifers (GWELLS) application is a primary source of groundwater information and data across the province. The GWELLS database is used to: i) support and inform groundwater allocation and water rights; ii) prioritize groundwater management initiatives; iii) support the protection of groundwater quality and groundwater remediation efforts; and, iv) serve as a public resource for groundwater information, education, and data.

As of August 2022, the GWELLS database contained over 1,270 aquifers. The province continues to conduct new aquifer mapping projects to expand and refine the database. The demand for mapping aquifers is ongoing as communities expand and new resource development projects are initiated. In addition, previously mapped aquifers are revisited periodically and updated as new information becomes available or a more detailed level of assessment is required. Aquifer mapping studies are prioritized based on several factors including: (i) local knowledge of emerging issues identified through regional work with communities; (ii) the location of water wells in the provincial GWELLS database that are not yet associated with a mapped aquifer; and (iii) the location of major resource development projects (e.g., mines, oil and gas).

In 2021/22, aquifers were mapped or revised in northeast B.C. within portions of the Halfway, Blueberry and Peace River valleys northwest of Fort St. John, and in the Cariboo area surrounding the community of 100 Mile House. This aquifer mapping information is used in groundwater allocation and licensing decisions under the *Water Sustainability Act* and is available to the public to inform groundwater well protection and land use planning.

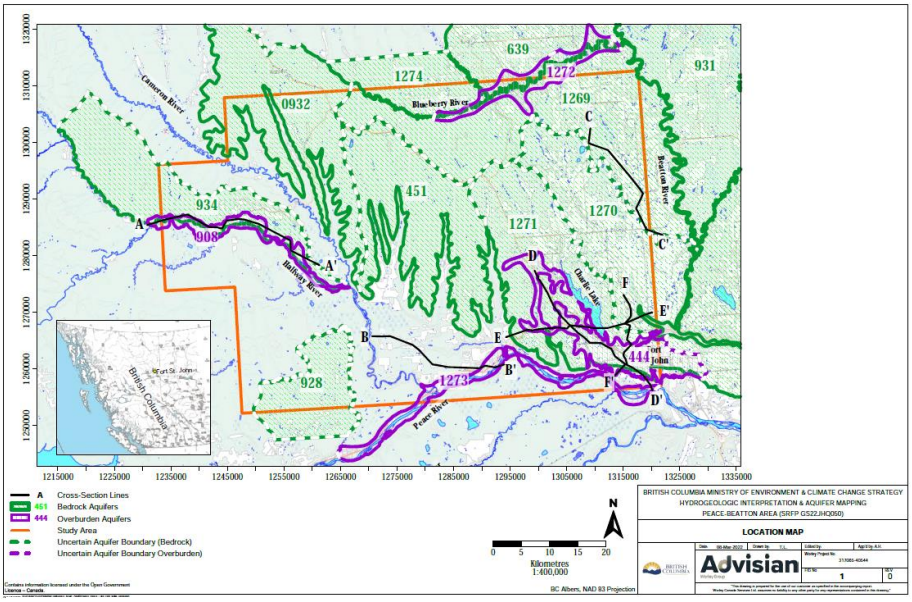
Spatial information about mapped aquifers can be accessed using the following tools:

- GWELLS – The Provincial database for storing and retrieving water well records and aquifer information;
- Groundwater Level Data Interactive Map Portal – a user friendly map-based tool to view and access information from the Provincial Groundwater Observation Network (PGOWN); and,
- iMapBC – view and analyze mapped aquifers along with hundreds of other data layers compiled from across the BC Government and other public-sector agencies. The provincial aquifer layer is named "Aquifers" and is found under the heading "Fresh Water and Marine."

Aquifer Mapping Studies, Northeast Region

Project Description

Phase 1 of the Northeast region aquifer mapping project focused on portions of the Halfway, Blueberry and Peace River valleys northwest of Fort St. John. Groundwater use is expected to increase with continued development in this region. Through identification and mapping of freshwater aquifers, this study provides a foundation for sustainable management of these resources. This project integrated water well records from the GWELLS database with information from previous hydrogeologic studies and mapping of geology, topography, streams and springs to map new and update existing aquifers.



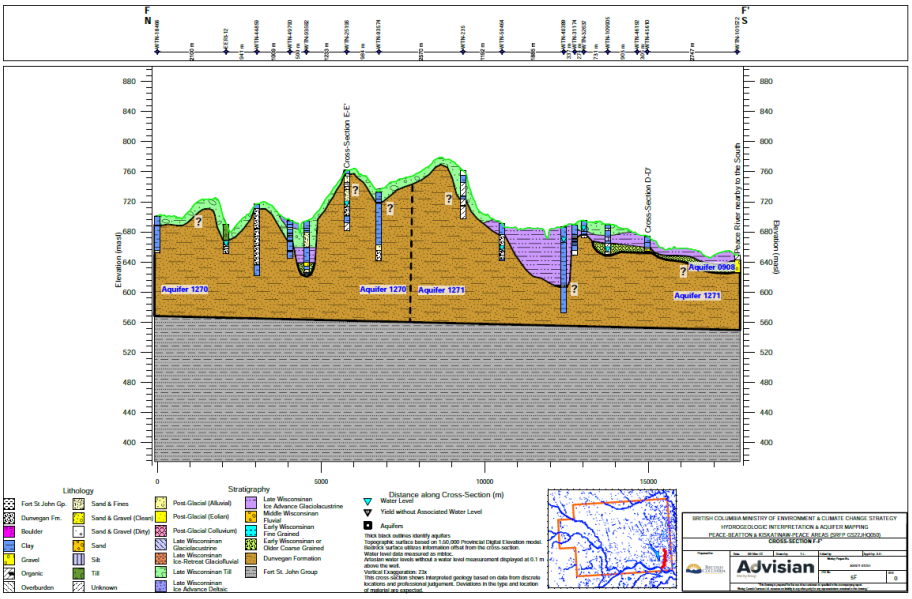
Project area location map; Peace-Beatton aquifer (Source: Lengyel et al., 2022).

Project Outcomes

Mapping of six existing aquifers were updated and six additional aquifers were mapped as an outcome of this study.

Relevance

Results will inform groundwater licensing under the *Water Sustainability Act*. Results may also be used to inform priorities for groundwater protection, studies of hydraulic connections with surface waters, and groundwater availability analyses.



Hydrostratigraphy of the Fort St. John area, cross-section F-F′ (Source: Lengyel et al., 2022).

References

Lengyel, T., A.C. Hinnell., and J.J. Clague. 2022. Peace-Beatton Aquifer Mapping and Hydrostratigraphic Characterization. Water Science Series, WSS2022-04. Province of British Columbia, Victoria.

Project Contacts

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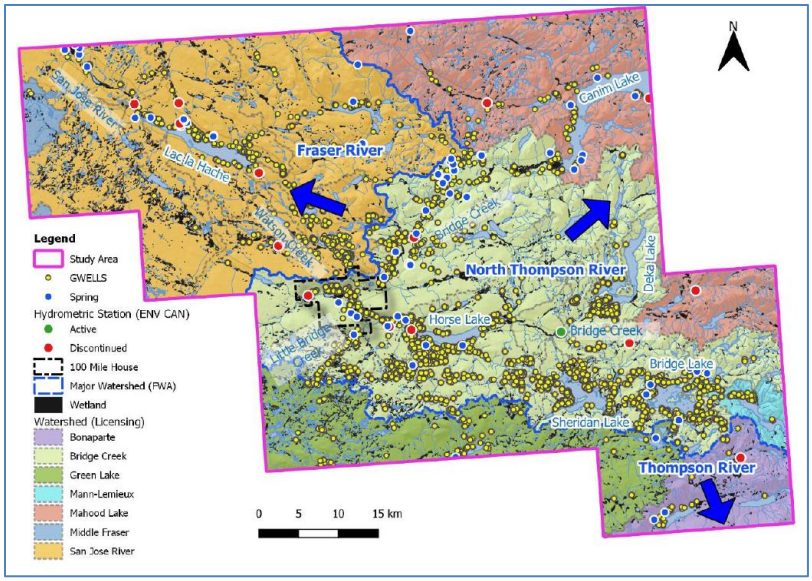
Acknowledgements:
Groundwater Science Program
Ministry of Forests, North Area Regional Operations

Aquifer Mapping Studies, Cariboo Region

Project Description

Phase 1 of the Cariboo area aquifer mapping project focused on an area of the southeastern extent of the Fraser Plateau surrounding the District of 100 Mile House. The area has several lakes, springs and wetlands. Through identification and mapping of freshwater aquifers, this study provides a foundation for understanding sustainable management of groundwater resources and a framework for understanding hydraulic connection with surface water features. This project integrated water well records from the GWELLS database with information from previous hydrogeologic studies and mapping of geology, topography, streams and springs to map new and update existing aquifers.



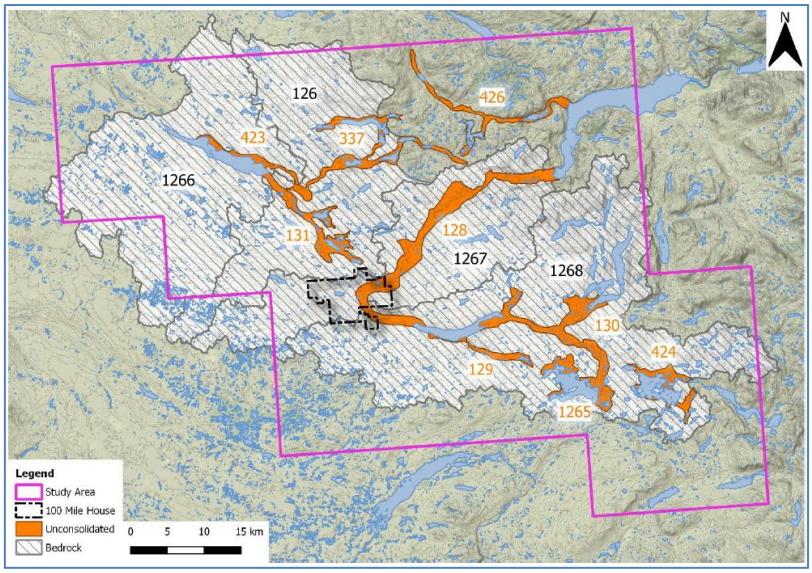
Surface water features and regional drainage for project area. (Source: Hammond et al., 2022).

Project Outcomes

Mapping of nine existing aquifers were updated and four additional aquifers were mapped as an outcome of this study. The aquifers have moderate to high productivity and generally have moderate vulnerability to contamination.

Relevance

Results will inform groundwater licensing under the *Water Sustainability Act*. Results may also inform priorities for groundwater protection, studies of hydraulic connections with surface waters, and groundwater availability analyses.



Updated aquifer mapping for Cariboo area (Source: Hammond et al., 2022).

References

Hammond, Z.,A.C. Hinnell, and J.J. Clague. 2022. Hydrogeologic Interpretation and Updated Aquifer Mapping in the Cariboo Area, Water Science Series, WSS2022-05. Province of British Columbia, Victoria.

Project Contacts

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Acknowledgements:
Groundwater Science Program
Ministry of Forests, South Area Regional Operations

2. GROUNDWATER MONITORING

The Provincial Groundwater Observation Well Network (PGOWN) monitors groundwater conditions in aquifers across British Columbia through provincially managed groundwater monitoring wells. The groundwater level measurements collected through the network helps inform water stewardship decisions across the province. Two main objectives of the network are:

1. Understanding local and regional hydrogeological processes; and,
2. Supporting the sustainable use of groundwater.

The data collected through the PGOWN is publicly available through several Provincial portals, including:

- The Interactive Map – includes all PGOWN information including the location of active and inactive monitoring wells; links to monitoring well construction reports; and groundwater level data and charts for real-time data and historical data.
- The Real-time Water Data Tool – is a browser-based information and data presentation system for access to continuous (time-series) surface, groundwater, snow monitoring data.
- The Environmental Monitoring System (EMS) Web Reporting – is an on-line search tool for surface and groundwater quality information stored in the EMS database.

The PGOWN was formally established in 1961 and the network has evolved with new observation wells added over time while others have been discontinued as priorities, staffing levels and funding levels have fluctuated. As of June 2022, there were 226 active observation wells in the PGOWN. During the 2021-22 fiscal year, two new observation wells were drilled and added to the network. The new observation wells (#503 near Chilliwack and 506 near Oliver) are described in the following project summaries.

In addition to expansion of the PGOWN, several projects were undertaken in 2021-22 to develop partnerships with First Nations on groundwater monitoring. In one project, Fort Nelson First Nations staff were trained to maintain and operate three PGOWN wells in the Fort Nelson First Nations area. A second project funded by Geoscience BC developed partnerships with First Nations in the Peace River region to install and operate co-located groundwater, surface water and climate monitoring stations.

Provincial Groundwater Observation Well #506 (Vaseux) near Oliver, B.C.

Project Description

The Provincial Groundwater Observation Well Network (PGOWN) monitors water levels and water quality in aquifers across B.C. to support effective and sustainable water management and to protect valuable groundwater resources. The Vaseux Provincial Groundwater Observation Well (OW 506) was installed in glaciofluvial deposits adjacent to Vaseux Creek near Oliver, B.C. to support long-term groundwater level monitoring in a location of regular water scarcity. This well also contributes groundwater information to local groundwater/surface water interactions research (see Vaseux Creek study summary, page 13).

Drill rig installing OW 506 on the Vaseux Creek alluvial fan.
Photo: N. Pyett

Project Outcomes

OW 506 was drilled to a depth of 29.7 metres below ground surface (mbgs) and was screened in Provincial Aquifer #255. The initial static water level in the well was 9.72 mbgs. An eight-hour constant rate pumping test was carried out on November 30, 2021. Drawdown during the pumping test stabilized quickly (97% of total drawdown within 1 minute) which may reflect a positive recharge boundary condition or may indicate the pumping rate (dictated by well screen sizing) did not sufficiently stress the aquifer. A rapid rebound of water levels after pump shut off (91% after one minute) suggests the aquifer is highly transmissive near OW 506. Water quality information is available through the B.C. Environmental Monitoring System (EMS ID E326591). Hourly water level monitoring data have been collected since March 26, 2022 and are publicly available through the B.C. Groundwater Level Data Interactive Map.

Relevance

Groundwater level monitoring in OW 506 will inform water management decision-making in an area of known water scarcity. Completion and testing of OW 506 provides valuable subsurface information related to morphology and development of the Vaseux Creek alluvial fan as well as preliminary aquifer and water quality parameters for the adjacent portion of Provincial Aquifer #255.

Learnings & Recommendations

A perched alluvial fan aquifer was not intercepted during drilling. The OW 506 groundwater level will be compared with groundwater levels in piezometers across the Vaseux alluvial fan and adjacent surface water levels to better understand groundwater/surface water interactions in the area.

Partners and Linkages

The following partners supported construction of OW 506: Okanagan Nation Alliance, Osoyoos Indian Band, The Nature Trust of British Columbia, and the Okanagan Basin Water Board.

References

Province of British Columbia. 2022. Well Record for Observation Well 506. GWELLS, Well Tag Number 125206.

Project Contacts

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Acknowledgements:
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Ministry of Forests, South Area Regional Operations

Provincial Groundwater Observation Well #503, Chilliwack, B.C.

Project Description

The Provincial Groundwater Observation Well Network (PGOWN) is intended to monitor groundwater conditions in selected aquifers throughout B.C. to support water management. In the South Coast Region, Observation Well #503 (OW 503) was installed in the City of Chilliwack to increase information about groundwater conditions in the unconfined sand and gravel Chilliwack-Rosedale Aquifer (Aquifer #6). This aquifer is a significant source of groundwater supply for domestic, industrial and agricultural users, and is likely connected to nearby streams. OW 503 was located near an existing hydrometric station on Elk Creek to help inform our understanding of groundwater-surface water interaction.

View of OW503 in Chilliwack.
Photo: K. Nguyen

Project Outcomes

Observation Well 503 was drilled on March 22, 2022 to a depth of 27.4 metres below ground surface and screened into the unconfined sand and gravel Chilliwack-Rosedale Aquifer (#6). Data loggers were deployed, and telemetry will be added to the station in the summer of 2022.

Relevance

OW 503 is the second observation well monitoring Aquifer #6, in addition to OW 450. OW 503 will provide improved data coverage for a large area with a reliance on groundwater extraction. Data collected from OW 503 will support water allocation and inform groundwater licensing and water management decisions.

Learnings & Recommendations

Groundwater level and chemistry data for OW 503 will be publicly available through the Groundwater Level Data Interactive Map and the provincial Aquarius time-series database Aquarius time-series database. Groundwater samples will also be collected for laboratory analyses, and the results will be publicly available through the B.C. Environmental Monitoring System (EMS ID E329431).

Partners and Linkages

The City of Chilliwack kindly allowed for the installation of this new well on their property and agreed to the use of this site for long-term groundwater monitoring.

References

Monahan, P., E. Young, C. Bieber, T. Back, M. Simpson, and M. Lepitre. 2019. Chilliwack Hydrostratigraphic Interpretation and Aquifer Mapping. Water Science Series, WSS2019-04. Prov. B.C., Victoria.

Province of British Columbia. 2022. Well Record for Observation Well 503. GWELLS, Well Tag Number 126214.

Project Contacts

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Acknowledgements:
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Ministry of Forests, South Coast Regional Operations

Provincial Observation Well Co-Monitoring Training in Fort Nelson Area

Project Description

Groundwater sampling demonstration and training at OW481. Photo: Jun Yin

This project aims to ensure ongoing monitoring and maintenance of three Provinicial Groundwater Observation Well Network (PGOWN) monitoring wells that were previously drilled, tested and developed in the Fort Nelson area. It is a collaborative effort between three B.C. government ministries and the Fort Nelson First Nation (FNFN) to increase our understanding of water resources and to initiate longterm groundwater monitoring in the Fort Nelson area. Provincial groundwater staff are providing ongoing training and coordination with the FNFN such that they will be able to fully support both the PGOWN observation wells, as well as any other industrial or local groundwater monitoring projects. The training combines classroom and field-based learning including: hydrogeology basics, Fort Nelson area hydrogeology, and PGOWN basics. Field practice includes YSI multimeter calibration and use, water level measurement and logging, water chemistry collection, and a brief introduction to the telemetry. Background information on establishing a local groundwater observation well network, and field guidance documentation will also provided to the FNFN.

Project Outcomes

FNFN training took place on May 11-12, 2022 by provincial groundwater staff who develivered the training on site. Eight FNFN members participated in the training. FNFN staff will continue to assist in ongoing well maintenance with a long-term vision of independent operation by the FNFN.

Relevance

The Fort Nelson area is identified as a key study area in the 2018 Liard-Petitot groundwater assessment study (Levson et al., 2018). To ensure high-quality groundwater monitoring data, it is essential to operate and maintain the wells according to PGOWN standards. In the North area, long driving distances limit the spatial coverage of monitoring sites. This initiative is a pilot project to collaborate with First Nations and to co-manage groundwater monitoring with indigenous groups.

Learnings & Recommendations

During the training, all three PGOWN wells were visited and sampled. The trainees showed excellent technical and field skills, as well as a keen interest to operate the wells independently. The success of this project supports ongoing collaboration and training of FNFN staff. This project may also serve as a model for similar collaborative efforts in other areas of the province.

Partners and Linkages

The project was approved and funded through B.C.'s Indigenous Funding Program in partnership with Fort Nelson First Nation.

References

Levson, V.M., H. Blyth, T. Johnsen and M. Fournier. 2018. Liard and Petitot Sub Basins Transboundary Groundwater Resources Assessment. Water Science Series 2018-01, Province of British Columbia, Victoria.

Project Contacts

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Strategic Water and Air Monitoring Planning Process (ENV)
Ministry of Forests, North Area Regional Operations

Coordinated Groundwater, Surface Water and Climate Monitoring in Northeast B.C.

Project Description

This project collaborates with Treaty 8 First Nations in the Peace River region to co-select and develop sites for partnerships on water monitoring. The sites have co-located water monitoring equipment for surface water, groundwater and climate monitoring to greatly expand collected water knowledge. The information generated creates opportunity for research and understanding into watershed processes. The project develops a learning foundation for partnership with First Nations in water monitoring through extended dialogue, a communications / engagement plan, multiple joint site visits, and increased capacity and training opportunities for First Nations. Project monitoring activities include: installation of groundwater monitoring wells for water quantity and quality where there may be groundwater–surface water interaction; surface water quality monitoring including benthic invertebrates; and installation of climate stations to monitor parameters such as rain, snow, relative humidity, wind speed and direction and solar radiation.

Project participants attending monitoring training in office and field settings.
Photo: D. Cottrell

Project Outcomes

Four groundwater wells were installed in March 2022 (Blueberry River, Alexander Creek, Stewart Creek and Hulcross Creek) – one climate station was installed in November 2021 (Stewart Creek), and water monitoring is occurring at all four sites and the Doig River. The sites selected for groundwater monitoring were the most suitable for interactions between surface water and shallow groundwater.

Relevance

The purpose of the groundwater wells is to monitor water levels in the shallow subsurface (unconfined aquifer), water quality in shallow groundwater, and ultimately – in coordination with the surface water monitoring – provide information about surface water-groundwater interaction. Some locations provided the added opportunity for testing the possible existence of a paleo-valley at a slightly deeper horizon.

Learnings & Recommendations

Data are being collected over the 2022 field season and will be summarized in a final report in March 2023.

Partners and Linkages

The project is supported through Geoscience BC – Pilot Collaborative Water Monitoring Program, Northeast BC, and in partnership with the B.C. Ministry of Energy, Mines and Low Carbon Innovation, the BC Oil and Gas Commission, and Shell Canada.

References

Lapp, S., D. Cottrell, E.G. Johnson, and T. Van Dijk. 2019. Pilot Collaborative Water Monitoring Program, Northeast BC. Geoscience B.C. Website: Accessed Aug. 8, 2022.

Lapp, S.L., E.G. Johnson, D.L. Cottrell, W.T. Van Dijk, B.P. Shepherd and R.L. Rolick, Pilot Collaborative Water Monitoring Program, Northeastern British Columbia (NTS 094A, Parts of 093O, P, 094B, G, H): Year One Update

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Acknowledgements:
Geoscience BC

3. GROUNDWATER CHARACTERIZATION AND RESEARCH

The provincial groundwater program supports ongoing groundwater science and research projects to promote effective groundwater resource stewardship and to provide a technical basis for groundwater policy development.

In 2021-22, a majority of groundwater science and research projects focused on characterizing the interaction between aquifers and hydraulically connected streams or lakes. Under the *Water Sustainability Act*, water is managed as one, interconnected resource and understanding surface water (SW) - groundwater (GW) interactions remains a high priority for resource managers and licensing staff. Most of the SW-GW interaction projects were field-based studies and one used a desktop assessment. The studies encompassed a variety of objectives and focus areas, including:

- Studies to characterize the location and dynamics of SW-GW interactions:
    - Nicola/Coldwater GW-SW Interactions Project
    - Assessment of GW-SW Interactions on the Vaseux Creek Alluvial Fan, Oliver, B.C.
    - Upper Bulkley Groundwater Interaction Project, Houston, B.C.
- Studies to characterize the ecological importance of SW-GW interactions:
    - An Ecological Assessment of Aquifer-Stream Connectivity in the Lower Fraser Valley
    - Groundwater Flow Patterns in shore spawning Kokanee Salmon Habitat Kootenay Lake
- Research to assess effects of post-harvest forest regeneration on runoff and SW-GW interaction
    - Shallow Groundwater Monitoring at Upper Penticton Creek, B.C. Interior Plateau
- Developing drought indicators and assessing the susceptibility of aquifers to drought
    - Identifying Drought Susceptible and Drought Resilient Aquifer-Stream Systems in B.C.

Other groundwater science and research projects undertaken in 2021-22 focused on improving knowledge and understanding of groundwater resources and groundwater use to directly inform resource management. These projects included:

- A groundwater well survey in the Bessette Creek area; and
- Mapping of flowing artesian wells and areas where flowing conditions are more likely to occur in the Okanagan Basin and Lower Fraser Valley

Nicola/Coldwater Groundwater-Surface Water Interactions Project, 2021

Project Description

To assess groundwater-surface water interactions in the Coldwater and Nicola Rivers near the City of Merritt B.C., the Ministry of Forests completed a field data collection program to further the research and include recommendations from the 2020 program. The 2021 monitoring program included installation and instrumentation of mini-piezometers along the rivers, and groundwater monitoring to collect hourly water levels and water temperature data. The project included surveying elevations of all monitoring sites, obtaining samples for water chemistry and isotopic analysis, measurement of streamflow, and compilation of water extraction records. Data analysis and assessments included identifying groundwater flow directions, vertical hydraulic gradients, temperature trends, pumping influences, streamflow analysis, and water chemistry. The project was undertaken to characterize the type of interactions between groundwater and surface water in the Nicola and Coldwater Rivers, adjacent aquifers and production wells.

Coldwater River near City of Merritt and City of Merritt monitoring well.
Photos: Cascades District staff & Laurie Lyons

Project Outcomes

The project report provides an updated analysis of the groundwater-surface water interactions in the Nicola and Coldwater Rivers and adjacent aquifers, effects of well pumping, and potential sources of recharge to the Upper Merritt aquifer.

Relevance

There is considerable interest in the interactions between the aquifers and river flows, and how pumping from wells may impact the river flow. The Nicola and Coldwater Rivers often experience water scarcity during summer months. In some years, the province has considered and implemented water restrictions.

Learnings & Recommendations

The project has provided a greater understanding of the complexity of groundwater-surface water interactions in the Merritt area, and provides opportunities for improved water management decisions, particularly during times of water scarcity.

Partners and Linkages

Project funding was provided by City of Merritt, Fraser Basin Council, and the Provincial Groundwater Science Program. The project was guided by the Fraser Basin Council and Nicola Basin Collaborative committees. The City of Merritt supported the project with access to the City of Merritt wells, and in-kind staff time.

References

Bennett, K. 2020. Analysis of City of Merritt Groundwater-Surface Water Data from Fall 2020. Golder Associates.

Gorski, N., R. Willis, J. Sarce and K. Bennett. 2018. Nicola Watershed Aquifer Classification and Mapping. Golder Associates.

Bennett, K., 2016. Lower Nicola Valley Groundwater Budget. Golder Associates.

Bennett, K. and A. Caverly. 2009. Review of Ground Water/Surface Water Interactions within the City of Merritt. B.C. Ministry of Environment.

Project Contacts

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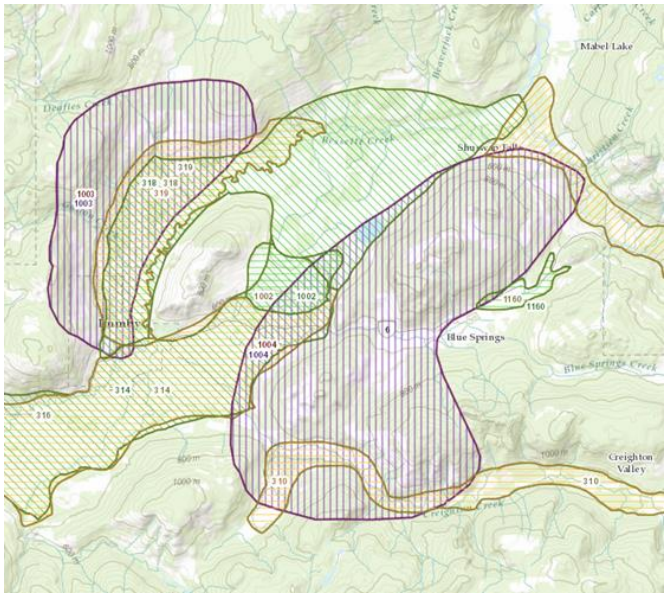
Acknowledgements:
Ministry of Forests, South Area Regional Operations
Fraser Basin Council
City of Merritt
Groundwater Science Program

Groundwater Well Survey in the Bessette Creek Area near Lumby, B.C.

Project Description

The Bessette Creek watershed near Lumby, B.C. is a productive agricultural area with known water scarcity issues. On August 20, 2021, a *Water Sustainability Act* (WSA) Fish Population Protection Order (FPPO) halted agricultural surface- and groundwater use during a low surface water flow period to protect aquatic ecosystem values. The Bessette Creek FPPO resulted in an estimated $3,000,000 in agricultural economic losses (Peterson, 2021). Water management decision-making and actions during times of water scarcity are informed by approaches that rely on groundwater data held in the Provincial GWELLS database. The Bessette Creek area was selected as the site of a project to improve groundwater data accuracy through direct contact with well owners.



Mapped aquifers in the Bessette Creek Watershed. Source: iMapBC

Project Outcomes

There were 207 properties visited over the course of the project resulting in 46 well co-ordinate change requests, registration of 27 previously unidentified wells, and identification of 25 inactive wells. This information was updated in the Provincial GWELLS database and is publicly available through Provincial mapping (iMapBC).

Relevance

The Bessette Creek area is expected to continue to experience drought events due to changes in water availability (volume and timing) related to climate change. This project created opportunities to better quantify key water budget parameters to inform water resource stewardship including drought response and groundwater allocation decisions. Refinement of drought support tools to reflect accurate "on the ground" conditions may decrease the number of impacted agricultural and other water users during times of water scarcity. The techniques used in this project for the Bessette Creek area can be applied to other river basins that have a substantial area of highly productive agricultural land, a history of known water scarcity, and high chance of recurring and severe drought events.

Learnings & Recommendations

This project was successful because efforts to collect groundwater data were coupled with dedicated support to reconcile findings with existing government databases. Collecting information without this support would likely result in significant delays between data collection and public and decision-maker data access.

Partners and Linkages

The project was completed with funding and support from the Ministry of Agriculture and Food.

References

Peterson, A. 2021. (2021 November 4). Ministry of Agriculture, Food & Fisheries: What were the impacts to farmers? [Oral presentation]. 2021 Thompson Okanagan Regional Drought Debrief, Kelowna, B.C.

Project Contacts

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Acknowledgements:
Ministry of Agriculture & Food
Ministry of Forests, South Area Regional Operations
Groundwater Science Program

Assessment of Groundwater/Surface Water Interactions on the Vaseux Creek Alluvial Fan, Oliver, B.C.

Project Description

The Vaseux Creek Groundwater/Surface Water Interactions Study is a three year project jointly managed by Ministry of Forests (FOR) and the Okanagan Nation Alliance (ONA) on the traditional lands of the Osoyoos Indian Band (OIB). snʕaẋəlqaxʷiyaʔ (Vaseux Creek) is a site of regular water scarcity-based conflict related to flow requirements for culturally significant fish species, anthropogenic water use demands, and the current hydrological regime. Analysis of data from installed hydrometric and groundwater monitoring equipment will inform our understanding of the dynamics between groundwater and surface water to support effective water management on this site.

snʕaẋəlqaxʷiyaʔ (Vaseux Creek)
Photo: Nicole Pyett

Project Outcomes

Year 1 of 3 included the development of a preliminary conceptual model, the installation of six hydrometric stations, eight groundwater level monitoring locations, and one Okanagan River level monitoring station, and the collection of preliminary water level and water quality data.

Relevance

Pressure on water availability is increasing in many locations across the province due to expanding development, land use changes, and effects from climate change. This study will develop an understanding of the relationship between snʕaẋəlqaxʷiyaʔ (Vaseux Creek) and the underlying aquifer, and will attempt to assess the impacts of water use on the system, to inform aquatic ecosystem recovery efforts and water management activities such as water licensing and drought response.

Learnings & Recommendations

Initial hydrometric data analysis indicates spatial and temporal variability in the quantity of water exchanged between snʕaẋəlqaxʷiyaʔ (Vaseux Creek) and the underlying aquifer during the low flow period. No layered or perched aquifers were observed during drilling across the alluvial fan. Isotopic analyses suggest at least two distinct water sources are recharging the aquifer. On-going data collection will develop understanding of groundwater-surface water interactions over the full hydrologic year. Development of hydrogeological cross-sections, mapping changes in water levels over time, and more clearly defining the hyporheic zone will inform further evaluation of groundwater and surface water flow dynamics.

Partners and Linkages

The project partners are the Okanagan Nation Alliance, the Osoyoos Indian Band, the Nature Trust of British Columbia, the University of British Columbia (Okanagan), and the Okanagan Basin Water Board.

References

Province of British Columbia. 2021. Well Record for Observation Well 506. GWELLS, Well Tag Number 125206.

Project Contacts

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Acknowledgements:
All project partners
Groundwater Science Program
Strategic Water and Air Monitoring Planning Process
Ministry of Forests, South Area Regional Operations

BRITISH COLUMBIA

An Ecological Assessment of Aquifer-Stream Connectivity in the Lower Fraser Valley (Phase 3)

Project Description

Environmental flow needs (EFN) must be considered for groundwater licensing decisions in B.C. under the *Water Sustainability Act* (WSA). Groundwater pumping near a stream can potentially alter aquifer–stream exchange and cause streamflow depletion, yet little is known about how aquatic ecosystems rely on groundwater, and the ecological impacts of groundwater pumping. A multi-year study (2018-2021) was conducted on Bertrand Creek at Otter Park in Langley, B.C. to evaluate the ecological role of aquifer-stream exchange, and to inform and support EFN determination for groundwater management.

SFU field program; data collection and field investigations.
Photos: Simon Fraser University.

Project Outcomes

Stream channel habitat variables (e.g., stream depth, velocity and substrate), water quality variables (e.g., pH, electrical conductivity and dissolved oxygen), and benthic macroinvertebrates were sampled at the Otter Park site over the summer of 2020. As streamflow conditions became drier over the summer, groundwater discharge maintained stagnant pools and some streamflow in riffles at downstream locations, despite streamflow declining to zero at the upstream hydrometric station. This allowed some macroinvertebrates to persist through a prolonged dry period in September 2020. Habitat models were constructed to relate macroinvertebrate responses to changes in hydraulic-habitat and water quality variables. The Hunt (1999) analytical streamflow depletion model was integrated with the habitat models for macroinvertebrates (built from data collected onsite) and for the endangered Nooksack Dace (built from literature-derived data) to assess how groundwater pumping scenarios might impact instream habitat for these organisms during different flow conditions. Other EFN assessment methods (e.g., wetted perimeter) were evaluated against the habitat models.

Relevance

Previous research at Otter Park showed groundwater pumping altered aquifer-stream exchange and caused streamflow depletion (Allen et al., 2020). An assessment of ecological responses to flow variability and an evaluation of potential tools to model ecological responses are critical future steps for understanding impacts from groundwater pumping.

Partners and Linkages

Dr. Diana Allen of the Department of Earth Sciences at Simon Fraser University supervised a master's student (Adam Mitton) to undertake this research. The Township of Langley provided the study location on their park land.

References

Mitton, A.J., Allen, D.M. and Nott, A. 2022. A Hydroecological Assessment of Hydraulic Connectivity: Phase 3 Field Investigation at Otter Park, Langley, B.C. Water Science Series, in preparation. Prov. B.C., Victoria.

Allen, D.M., B. Johnson, A. Garnet, K. Howe, M. Lepitre, and M. Simpson. 2020. Assessment of Aquifer-Stream Connectivity Related to Groundwater Abstraction in the Lower Fraser Valley: Phase 2 Field Investigation at Otter Park, Langley. Water Science Series Report, WSS 2020-03. Prov. B.C., Victoria.

Hunt, B. 1999. Unsteady stream depletion from ground water pumping. *Groundwater*, 39(1): 98-102.

Project Contacts

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Acknowledgements:
Groundwater Science Program
Ministry of Forests, South Coast Regional Operations

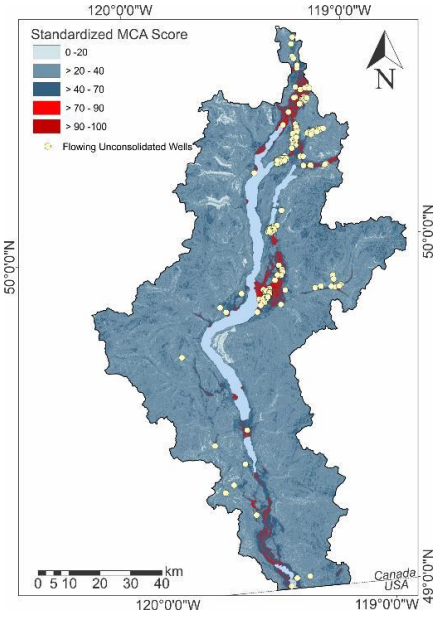
Mapping and Mitigating Risk of Flowing Artesian Wells in B.C.: Okanagan Basin and Lower Fraser Valley

Project Description

The goals of this project were to develop a more comprehensive understanding of the factors controlling where flowing artesian conditions occur and where there is greater risk when drilling into those conditions, and to examine how current policies and regulatory requirements regarding flowing artesian wells could be enhanced.

Project Outcomes

Multi-Criteria Analysis (MCA) was used to map where flowing artesian conditions are 'more likely than not' to occur. Maps were produced for three hydrogeological contexts: Okanagan Unconsolidated (see figure); Okanagan Bedrock; and Fraser Valley Unconsolidated. All maps show areas of high and moderate risk for flowing artesian conditions. The statistical method used to validate the maps indicated that the MCA maps accurately determined the extent of flowing artesian conditions in each hydrogeological context. All maps also have areas where flowing artesian conditions are 'more likely than not' but do not have any (or few) known flowing wells. The absence of flowing wells in these areas does not necessarily indicate the maps are incorrect, as flowing wells may just not have been drilled yet.



Map showing MCA scores for unconsolidated aquifers in the Okanagan Basin. Source: Johnson et al., 2022.

Relevance

Flowing artesian wells are a known problem in many regions of B.C., particularly in the Lower Fraser Valley and the Okanagan. If allowed to flow uncontrolled, these wells may eventually impact the long-term sustainability of the aquifer, leading to reduced water yield from wells and springs, and reduced natural groundwater discharge to streams which can impact aquatic habitat. Moreover, flowing artesian wells can increase the risk of subsidence or sinkholes, as occurred recently in the City of Vancouver. The result can be extensive property damage, loss of property value, and excessive costs to the property owner, and constraints on future land use. Controlling artesian flow is a requirement of the *Water Sustainability Act* (S. 52 and 53)

Learnings & Recommendations

This project yielded insight into the hydrogeological factors that control the occurrence of flowing artesian wells. The MCA maps can provide guidance for well drillers and groundwater consultants. The maps can be used in conjunction with known flowing (and non-flowing) well locations to inform decisions around drilling and preparation, well design, and cost. The maps can also be used to identify areas that should be more closely examined or monitored, or areas where a Flowing Artesian Conditions Advisory may be warranted. The project aimed to support regulatory requirements for controlling artesian flow by providing better understanding of where such conditions occur.

Partners and Linkages

The project was carried out by Dr. Diana Allen (Professor) and Brynje Johnson (M.Sc. student) in the Department of Earth Sciences at Simon Fraser University, and Mike Wei (Hydrogeologist) at HydroGeoLogic.

References

Johnson, B., D.M. Allen, and Wei, M. 2022. Mapping the Likelihood of Flowing Artesian Conditions in the Okanagan Basin and Fraser Valley, British Columbia. Water Science Series, WSS2022-03. Province of British Columbia, Victoria

Project Contacts

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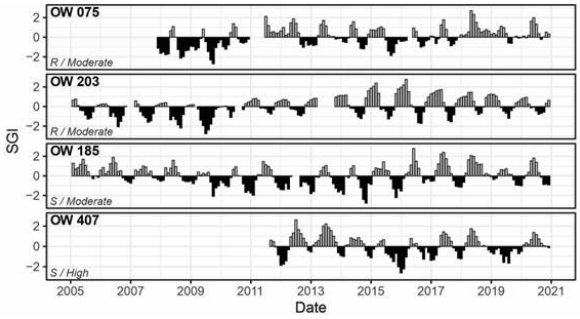
Acknowledgements:
Groundwater Science Program
Ministry of Forests, South Coast Regional Operations

Identifying Drought Susceptible and Drought Resilient Aquifer-Stream Systems in British Columbia

Project Description

Understanding how drought affects the linkages between groundwater levels and connected surface water flows in nearby streams is central to decision-making surrounding water use and the protection of water resources during periods of drought. This project was to develop approaches for determining the susceptibility of aquifer-stream systems to drought in B.C., and to test this approach in the Okanagan Basin. This multi-year project aimed to: 1) develop quantitative drought indicator thresholds for groundwater levels; 2) evaluate these indicators and decision-support tools used during water scarcity; and 3) to identify susceptibility of aquifers to drought in the Okanagan Basin.



Standardized Groundwater Level Index (SGI) for selected provincial observation wells.

Project Outcomes

During the third and final year of this multi-year project, research efforts focused on: 1) identifying early season and drought season indicators of groundwater drought derived from groundwater level, streamflow and climate data; and 2) identifying drought susceptible aquifers in the Okanagan basin. The results of this phase of the project are intended to help develop approaches to identify climate indicators and observation wells that could serve as early indicators of groundwater drought, and to identify those aquifers that may be susceptible to drought.

Learnings & Recommendations

Generalized additive models (GAMs) were used to determine which combinations of early season climate and hydrological predictor variables (indicators) are associated with summer groundwater levels. In the snowmelt-dominated hydrologic regime of South-Central B.C., maximum spring temperature, maximum snow water equivalent, and the winter Nino 3.4 index are the best combination of predictor variables. In the rainfall-dominated hydrologic regime of the Fraser Valley, maximum spring temperature, winter precipitation, and spring streamflow are the best combination of predictor variables. The Standardized Groundwater Level Index (SGI) was also used to identify wells and aquifers that had pronounced responses to drought. However, the SGI was shown to be affected by water use in aquifers and as such may not be best used in aquifers with a high well density or negative groundwater trends. Aquifers in the Okanagan were classified for drought susceptibility using estimates of hydraulic diffusivity by aquifer type and well density. The classification identified five highly susceptible aquifers and 23 moderately susceptible aquifers.

Partners and Linkages

Dr. Diana Allen of the Department of Earth Sciences at SFU supervised a Master of Science student, April Gullacher, to undertake this research. Project funding was provided by the Canadian Mountain Network and the Groundwater Science Program. Project support was provided by the BC River Forecast Centre, LWRS Water Protection and Sustainability Branch and ENV Knowledge Management Branch, the Ministry of Forests, the Okanagan Basin Water Board, the Okanagan Nation Alliance, and the University of Victoria.

References

Allen, D.M., A. Gullacher, and J. Goetz, 2022. Early Season Groundwater Drought Indicators in Mountainous Regions. Water Resources Research. Manuscript submitted for publication.

Gullacher, A., D.M. Allen, and J. Goetz, 2022. Indicators of Groundwater Drought in British Columbia. Water Science Series. Province of British Columbia, Victoria. Submitted for publication.

Project Contacts

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Acknowledgements:
Groundwater Science Program
Canadian Mountain Network

Shallow Groundwater Monitoring at Upper Penticton Creek, B.C. Interior Plateau

Project Description

The Upper Penticton Creek (UPC) Watershed Experiment was established in 1984 as interior BC's only long-term, paired watershed experiment. The primary focus of the research has been to determine how snow accumulation, snowmelt, streamflow quantity/quality, and the hydrologic regime are affected by clearcut logging relative to an unlogged control (Winkler et al., 2021). Phase 2 of the research is currently focused on the effects of post-harvest forest regeneration on the same hydrologic parameters as Phase 1. However, research is also being conducted to characterize runoff generation and groundwater-surface water interactions in these watersheds.

Twenty-one shallow (0.5-1.2 m deep) groundwater wells were installed across 240 Creek (control) and 241 Creek (logged) watersheds during summer 2021. An additional 18 wells will be installed this summer. Wells were installed in groups with two orientations: 1) in transects from the riparian area to upslope areas; and 2) longitudinally along ephemeral stream reaches.

Well transects will be used to determine when hydrological connectivity occurs (i.e., when the hillslope is connected to the stream through subsurface flow) by the presence of a perched water table in all wells. These data will also be used to quantify streamflow and subsurface responses to snowmelt and storms during variable soil moisture conditions. Longitudinal wells will be used to monitor the ephemeral nature of the streams and determine how forest regeneration may be influencing the shallow water table and groundwater-surface water interactions.

Shallow wells in riparian zone (top) and upslope area (bottom).
Photo: S. Spencer

Project Outcomes

This long-term monitoring project is in its initial stages so there are currently no results to report. However, results from this research will help us understand the resilience or resistance of a watershed to forest disturbance, the influence of subsurface storage on hydrological responses to storms, and the potential for downstream flooding.

Partners and Linkages

Current research at UPC is supported by Dr. Adam Wei at the Department of Earth, Environmental and Geographic Sciences, UBC Okanagan.

References

Winkler, R.D., D.M. Allen, T.R. Giles, B.A. Heise, R.D. Moore, T.E. Redding, D.L. Spittlehouse and X. Wei. 2021. Approaching Four Decades of Forest Watershed Research at Upper Penticton Creek, British Columbia: A Synthesis. Hydrological Processes, **35**, https://doi.org/10.1002/hyp.14123.

Project Contacts

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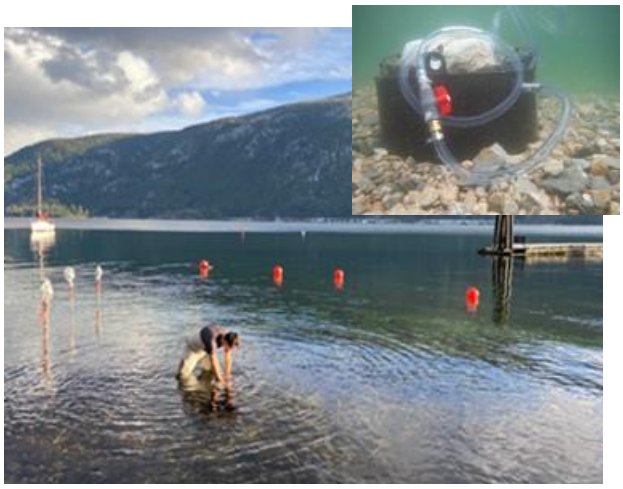
Acknowledgements:
Water Research Portfolio, Ministry of Forests

Groundwater Flow Patterns in Shorespawning Kokanee Salmon Habitat, West Arm of Kootenay Lake

Project Description

A small but important population of Kokanee Salmon spawn in areas of upwelling groundwater along the shoreline of Kootenay Lake. Lake drawdown occurs over the winter egg development period for hydroelectric power generation, stranding fry and reducing the number that successfully emerge from the gravels. Efforts are underway to enhance spawning habitat lower in the water column to avoid egg dewatering over the winter. However, little is known about how groundwater upwelling rates change with lake level. In this project, multiple methods are being used to assess groundwater upwelling rates and patterns, changes over the winter egg development period and the effects of changing water level on groundwater flow patterns.



Monitoring groundwater flow using seepage meters, temperature profiles and water chemistry.
Photo: N. Neumann

Project Outcomes

A graduate student was engaged to design and implement the first winter season of field data measurements in 2021-22. Groundwater flow rates across the lakebed were measured over the winter using seepage meters and vertical temperature profiles, water samples were collected for isotope and major ion chemistry analysis, and the gradient between the local water table and the lake was monitored.

Relevance

Results from this research will improve the efficacy of physical habitat enhancement projects (e.g., substrate addition).

Learnings & Recommendations

The first year of field data is being analysed. A major challenge has been to install equipment and conduct measurements with lake level changes of more than 1 m between October and April.

Partners and Linkages

Dr. Ed Hornibrook at the University of British Columbia Okanagan is co-supervising the graduate student undertaking this research. This work complements a habitat enhancement project underway by the Friends of Kootenay Lake Stewardship Society, who is a major partner. The study site is in McDonalds Landing Regional Park, managed by the Regional District of Central Kootenay.

Project Contacts

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Acknowledgements:
Water Research Portfolio, Ministry of Forests

Upper Bulkley Groundwater Interaction Project, Houston, B.C.

Project Description

Located near Houston B.C., the Upper Bulkley River watershed system has both a shallow valley fill aquifer with strong connections to surface water, and a separate deeper aquifer for which surface water connectivity is less well understood. This project will assess how these water sources interact to guide resource management in the area.

Initiated in 2018, the four-year project uses thermal imagery to guide traditional groundwater level and flow monitoring. At identified seepage locations, seepage meters and piezometers are placed in cross sections to monitor the flux of groundwater into the stream. Additionally, volunteer domestic wells are monitored to understand seasonal variability in the aquifer system. One more season of field work is planned prior to completing a final report and data sharing with stakeholders, First Nations and water management staff.

Stream instrumentation.
Photo: J. Wick

Project Outcomes

The intended outcome of the project is to strategically collect data to inform management of the water resources in the Upper Bulkley River watershed. To date, data loggers have been installed in five volunteer wells, ortho- and thermal-imagery from drone flights have been compiled to inform site selection, and piezometers and seepage meters have been installed at selected sites to monitor and record discharge and groundwater levels.

A thorough grasp of the interactions between groundwater and surface water, existing water allocation pressures, and Environmental Flow Needs (EFN) must be understood by water managers in order to make informed and durable water allocation decisions. This project aims to fill current knowledge gaps, particularly where there are implications for EFN.

Relevance

The Upper Bulkley River watershed serves as a critical spawning and rearing area for pacific salmon and steelhead trout, and as a source of water for a variety of users. The watersheds natural propensity for low water conditions and high water temperatures raises considerations for water management in the area. The impact that groundwater withdrawals can have on stream flow has led to an interest in assessing hydraulic connectivity and its relationship to EFNs in the Upper Bulkley River watershed.

Learnings & Recommendations

There have been extensive learnings on the technical aspects of installing and monitoring seepage meters and piezometers, as well as using drone thermal imagery. Additionally, it is recommended that dedicated monitoring wells be installed where possible to minimize the impacts of water use and well effects on aquifer data collection.

Partners and Linkages

Project development and data sharing partners will include: The Office of the Wet'suwet'en; The Wet'suwet'en First Nation; The Upper Bulkley River Streamkeepers; The District of Houston; The Regional District of Bulkley-Nechako; Fisheries and Oceans Canada; local residents who volunteered wells and the B.C. Ministry of Forests.

Project Contacts

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Acknowledgements:
Water Research Portfolio, Ministry of Forests

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- B.C. Oil and Gas Commission
- B.C. River Forecast Centre
- Canadian Mountain Network
- Friends of Kootenay Lake Stewardship Society
- Fisheries and Oceans Canada
- HydroGeoLogic
- Geoscience BC
- Ministry of Agriculture and Food
- Ministry of Energy, Mines and Low Carbon Innovation
- Ministry of Environment and Climate Change Strategy
- Ministry of Forests
- Ministry of Land, Water and Resource Stewardship
- Okanagan Basin Water Board
- Shell Canada
- Simon Fraser University
- The City of Chilliwack
- The City of Merritt
- The District of Houston
- The Fort Nelson First Nation
- The Fraser Basin Council
- The Nicola Basin Collaborative
- The Office of the Wet'suwet'en
- The Okanagan Nation Alliance
- The Osoyoos Indian Band
- The Nature Trust of British Columbia
- The Regional District of Bulkley-Nechako
- The Regional District of Central Kootenay
- The Township of Langley
- The Upper Bulkley River Streamkeepers
- The Wet'suwet'en First Nation
- University of British Columbia Okanagan
- University of Victoria